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Powering AI: Additionality and Nuclear Power

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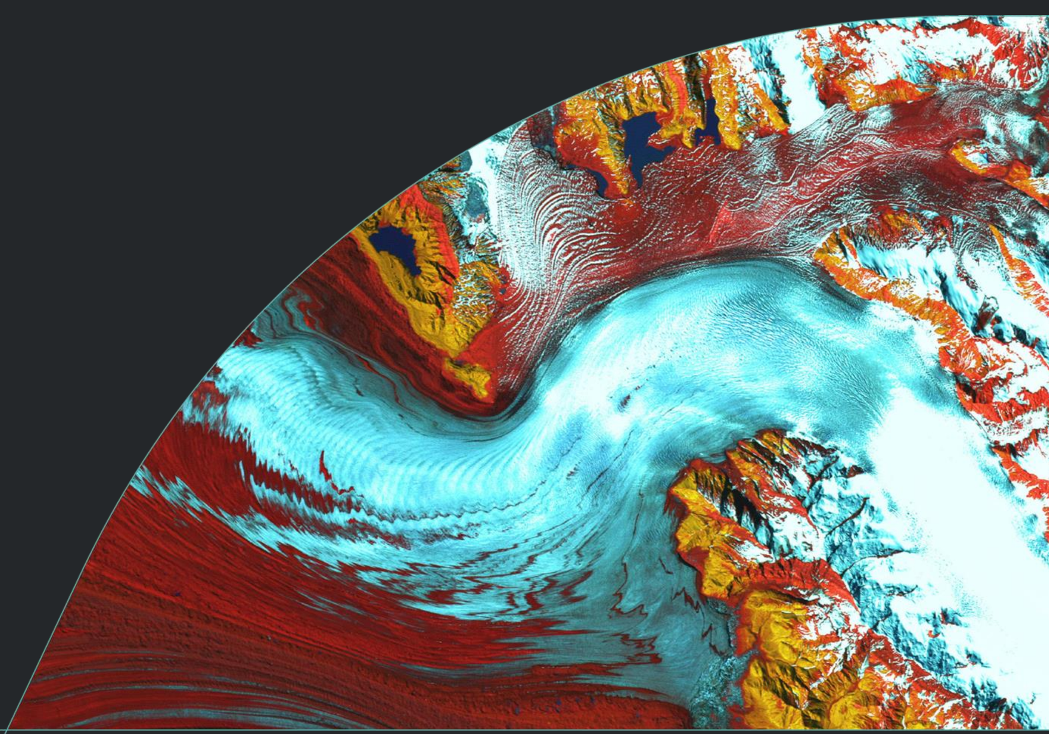

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Definitions

Additionality	The principle is that renewable energy projects should create new clean energy capacity beyond what would have occurred without access to carbon market incentive mechanisms.
Carbon Dioxide Removal (CDR)	Technologies and processes that remove carbon dioxide from the atmosphere, such as direct air capture (DAC) and ocean alkalinity enhancement (OAE).
Direct Air Capture (DAC)	Technologies that extract CO_2 directly from the atmosphere at any location, unlike carbon capture which is generally carried out at the point of emissions, such as a steel plant.
Leakage	The phenomenon where actions intended to reduce emissions in one area inadvertently lead to increased emissions elsewhere.
Power Purchase Agreement (PPA)	A long-term contract between an electricity generator and a power purchaser, typically spanning 10 to 20 years.
Server Farm	A large-scale data center housing thousands of servers that process and store vast amounts of data to support AI applications like machine learning, natural language processing, and image recognition.

Abstract

This article examines the intersection of artificial intelligence's (AI) growing energy demands, renewable energy procurement, and carbon markets through the lens of additionality. The growing demand for AI server farms – large-scale data centers housing thousands of servers that process and store vast amounts of data to support AI applications – is straining global power systems, leading to scrutiny of traditional “green” energy procurement methods like power purchase agreements (PPAs) for their true environmental impact. Technology companies' renewable energy strategies may inadvertently compete with broader decarbonization efforts and may explain their recent pivot toward nuclear energy. There are critical parallels between the technology sector’s challenges, broader grid and transportation decarbonization efforts, and the emerging carbon dioxide removal (CDR) industry. All these sectors require additional power sources to claim low emissions and avoid accusations of greenwashing. The unique characteristics of nuclear power – unambiguous additionality, baseload generation, and separate resource chains – make it an ideal solution for powering both AI and, perhaps, CDR technologies while ensuring true emissions reductions. While nuclear power faces significant challenges, including high capital costs, long construction timelines, and waste management considerations, the pressing need for large-scale, reliable, clean energy to power our digital future and climate solutions may justify embracing these complexities.

Introduction

Data centers currently account for about 1% to 1.5% of global electricity use, according to the International Energy Agency (IEA).[1] At current trends in AI capacity, NVIDIA, a leader in graphics processing units (GPUs), which are critical for gaming, data visualization, and AI applications, will ship around 1.5 million AI server units per year by 2027. These 1.5 million servers, running at full capacity, would consume at least 85.4 terawatt-hours (TWh) of electricity annually.[2] The unprecedented scale of AI power consumption, driven by the growing demand for energy-intensive data centers, has become a defining challenge of our time and one of the largest obstacles to achieving climate goals due to its significant contribution to global carbon emissions and the increasing strain it places on renewable energy sources. As competition in the AI space intensifies, providing these services has become a non-negotiable imperative for technology companies. How can they power their newly built server farms and reduce their carbon footprint at the same time?

In recent years, carbon markets have emerged as a key mechanism for incentivizing emissions reductions and driving the transition to cleaner energy sources. Within this context, PPAs are an important tool, serving as a bridge between renewable energy projects and carbon markets. PPAs allow companies to claim emissions reductions by directly supporting the development of new renewable energy projects. These agreements often generate renewable energy certificates (RECs) or similar instruments that can be used within voluntary carbon markets (VCMs) to meet self-imposed goals or used for regulatory compliance requirements.

[1] https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks#overview
[2] https://www.cell.com/joule/abstract/S2542-4351(23)00365-3

However, the effectiveness of these markets and the role of PPAs within them hinge on several crucial concepts common to all carbon reduction products: additionality, leakage, and permanence. These principles form the foundation for evaluating the true impact of renewable energy projects and corporate sustainability initiatives. They also form the core of the International Organization for Standardization (ISO) standard for greenhouse gas (GHG) emissions and removals ISO 14064-2.[3] These concepts can be summarized as:

- **Additionality:** The requirement that projects generate emissions reductions that would not have occurred in the absence of carbon market incentives is fundamental to ensuring that these mechanisms drive genuine change. A project can only be considered additional if it requires the revenue or other benefits from carbon markets to be viable – simply building a project that reduces emissions is not enough to prove additionality.
- **Leakage:** The unintended consequence in which emissions reductions in one area lead to increases elsewhere presents a significant challenge to the integrity of carbon reduction efforts. This is particularly relevant in the context of PPAs and their impact on overall grid emissions.
- **Permanence:** The long-term stability of emissions reductions is crucial for achieving lasting climate impact. In the realm of renewable energy, this concept intersects with questions of grid reliability, energy storage, and the life cycle of renewable energy infrastructure.

Permanence for power projects is easy to calculate, as replacing fossil fuel plants with renewables permanently reduces GHG emissions. However, this article argues that using renewable energy to power new AI data centers is likely to fail both additionality and leakage tests. The same applies to CDR and the electrification of transportation, both of which are likely to slow a reduction in grid carbon emissions.

Project proponents of CDR technologies, such as direct air capture (DAC), should take heed. As these nascent technologies scale up to meet climate goals, they, too, will contribute significantly to power demand. The power sources must meet the stringent scrutiny of ISO 14064-2. Climate goals will not be well served if natural gas power plants are used to power carbon removal facilities. Climate mitigation projects, be it carbon removal or avoidance from, say, transportation electrification, must also be looking outside of the box to find power that would otherwise have been used to decarbonize homes and businesses.

Additionality, Leakage, and Renewable Projects

Additionality and Power

Additionality refers to the principle that projects or actions should create new, additional environmental benefits beyond what would have occurred. In the power sector, this concept is

[3] ISO 14064-2 is an international standard that provides guidelines for the quantification, monitoring, and reporting of greenhouse gas (GHG) emissions and removals from specific projects or activities. The standard was first published in 2006 and has since been revised twice, with the latest version released in 2019.

used when evaluating the impact of renewable energy purchases and investments. Additionality determines the extent to which a new action or intervention leads to a net positive outcome compared to a baseline. In the context of renewable energy, this means that a project should result in new clean energy capacity that would not have been built otherwise.

A common mechanism for procuring renewable energy for a project is to use a PPA. A PPA is used as a way of transferring the environmental attribute from a power facility (e.g., a solar array) to a purchaser. PPAs establish the terms under which a power purchaser, often a corporation or utility, agrees to buy electricity from a renewable energy project.

PPAs offer several benefits to buyers, including long-term price stability for electricity costs, the ability to claim the use of renewable energy and associated emissions reductions, and support for new renewable energy projects, potentially contributing to additionality. For sellers, PPAs provide a guaranteed revenue stream, facilitating project financing, and reducing market risk through long-term contracts.

Do PPAs Meet Additionality Requirements?

Permitting timelines for large-scale renewable energy projects, such as utility-scale solar or wind farms, typically range from 10 to 25 years.[4] This extended timeline creates several challenges for PPAs and additionality. Power projects already advanced in the permitting process when a PPA is signed may not be considered additional, as they might have been built regardless of the PPA.

These challenges could lead to a situation where technology companies' efforts to procure renewable energy through PPAs do not result in the intended additionality. In some cases, companies may end up signing PPAs for projects that were already likely to be built, effectively reallocating existing clean energy rather than driving new capacity. Rather than decarbonizing homes, the newly built wind turbines allow a corporation to decarbonize its new server farm. This is where the concept of leakage occurs. The intervention did not decarbonize the economy; it simply shifted (leaked) the emissions from the server farm to everyone else connected to the grid that is outside the boundaries of the project.

The challenge of ensuring additionality in renewable energy projects has been underscored by a recent decision from the Integrity Council for the Voluntary Carbon Market (ICVCM). In August 2024, the ICVCM announced that carbon credits issued under existing renewable energy methodologies, which account for nearly a third of the VCM, will not be eligible to meet its high-integrity, science-based Core Carbon Principles (CCP). The ICVCM Governing Board determined that eight methodologies used to design and implement renewable energy projects fail to meet the CCP Assessment Framework requirements on additionality. These methodologies were found to be insufficiently rigorous in assessing whether the projects would have proceeded without the incentive of carbon credit revenues. This decision affects approximately 236 million unretired credits, making up 32% of the VCM. The ICVCM's stance highlights the growing scrutiny of additionality claims in renewable energy projects and calls for

[4] https://betterbuildingssolutioncenter.energy.gov/financing-navigator/option/power-purchase-agreement

more sophisticated approaches to assessing whether such projects truly result in additional emissions reductions.[5]

Leakage

While we have already explored leakage in the context of grid emissions, where actions intended to reduce emissions in one area lead to increases elsewhere, there is another, more subtle form of leakage that threatens global decarbonization efforts: competition for resources. This competition extends far beyond the simple demand for renewable energy projects and manifests in multiple interconnected ways that can inadvertently slow the pace of global decarbonization.

First, there is direct competition for physical resources and manufacturing capacity, which can lead to genuine emissions leakage. When technology companies secure large quantities of solar panels, wind turbines, or battery storage systems for their projects, they can effectively corner the market, driving up prices and extending wait times for other potential buyers. This can force smaller organizations, municipalities, and developing nations to delay their renewable energy projects and instead rely on more readily available fossil fuel infrastructure to meet their immediate power needs. This creates true emissions leakage: while the technology companies reduce their reported emissions through renewable energy projects, they inadvertently force other entities to increase their emissions by turning to fossil fuel alternatives. The net result will be a slower pace of grid decarbonization.

This resource competition extends to financial and operational capital as well. Large technology companies' aggressive pursuit of renewable energy projects can absorb much of the available project finance capacity, contractor bandwidth, and interconnection queue positions. When combined with their ability to secure long-term PPAs at premium prices, this can effectively crowd out other potential clean energy developments, particularly in regions where grid connection or construction capacity is limited. The result might be a slower overall pace of global decarbonization, even as individual companies make progress toward their sustainability goals.

The competition for limited clean energy resources has real-world consequences on the deployment of new technologies, as well as ongoing decarbonization. For example, in September 2024, CarbonCapture Inc. announced it was pausing deployment of what would have been the world's largest DAC facility in Wyoming.[6] The company was unable to secure the necessary renewable energy and grid connections because data centers had already claimed much of the available capacity. This case demonstrates how constrained resources – both renewable energy supply and grid infrastructure – can create bottlenecks for scaling climate solutions. When multiple rapidly growing sectors compete for the same limited clean energy resources, some projects will inevitably be delayed or abandoned.

This situation creates a paradoxical dynamic in the technology industry's climate efforts. While companies like Microsoft and Google are significant carbon purchasers of removal credits and

[5] https://icvcm.org/carbon-credits-from-current-renewable-energy-methodologies-will-not-receive-high-integrity-ccp-label/
[6] https://cowboystatedaily.com/2024/09/03/giant-wyoming-carbon-capture-project-pulls-plug-for-lack-of-clean-power/

supporters of DAC technology, their rapidly expanding AI operations are simultaneously making it harder for DAC facilities to secure the clean energy they need to operate. As Kajsa Hendrickson, Director of Policy at Carbon180, has been quoted as saying, "You have Microsoft, who may be putting all of the money in to build a data center but then who's also buying CDR credits, and I think that makes for a really interesting conundrum."[7] This feedback loop underscores why traditional renewable energy procurement strategies are insufficient.

The Nuclear Solution

The technology industry's recent shift towards nuclear power, exemplified by Google's groundbreaking initiative of committing to purchase 500 megawatts (MW) of nuclear energy by 2035 from multiple small modular reactors to be developed by California-based Kairos Power,[8] represents the most promising approach to energy procurement that addresses many of the resource competition issues discussed previously. Under the agreement, Kairos Power will develop, construct, and operate a series of small modular reactor (SMR) plants and sell energy, ancillary services, and environmental attributes to Google under PPAs. Kairos Power's SMR safety systems are state-of-the-art, making them as safe or safer than conventional energy sources, according to the U.S. Nuclear Regulatory Commission (NRC).[9] Plants will be sited in relevant service territories to supply clean electricity to Google data centers, with the first deployment by 2030 to support Google's 24/7 carbon-free energy and net-zero goals.

Meanwhile, social media giant Meta recently announced[10] plans to collaborate with nuclear power developers to help meet its AI innovation and sustainability objectives, targeting between 1-4 gigawatts (GW) of new nuclear generation capacity in the U.S. to be delivered starting in the early 2030s. Following the announcement about its nuclear power endeavors, Meta unveiled plans to invest $10 billion in constructing its largest AI data center in Richland Parish, Louisiana.[11] This hyper-scale facility will handle massive data processing demands essential for advanced digital infrastructure and AI workloads.

The unique characteristics of nuclear power make it particularly suitable for meeting large-scale, constant power demands. It is one of the lowest emission forms of energy when considering full lifecycle emissions (see Table 1). However, these calculations must include not only construction and uranium mining but also long-term waste management and storage requirements. The total lifecycle emissions remain comparable to wind and solar (PV) energy, even when accounting for these additional factors.

[7] https://www.latitudemedia.com/news/inside-project-bisons-battle-for-clean-power
[8] https://blog.google/outreach-initiatives/sustainability/google-kairos-power-nuclear-energy-agreement/
[9] https://www.nrc.gov/docs/ML2420/ML24200A115.pdf
[10] https://sustainability.atmeta.com/blog/2024/12/03/accelerating-the-next-wave-of-nuclear-to-power-ai-innovation/
[11] https://www.entergynewsroom.com/news/entergy-louisiana-power-meta-s-data-center-in-richland-parish/

Table 1: Full Lifecycle Analysis (LCA) Emissions per Kilowatt-Hour (kWh) for Different Forms of Electricity Generation

Source of Power	Emissions per kWh
Coal	710–950 g CO_2e/kWh
Oil	510–1170 g CO_2e/kWh
Gas	410–650 g CO_2e/kWh
Photovoltaic (PV) Solar	18–180 g CO_2e/kWh
Concentrated Solar Power (CSP)	9–63 g CO_2e/kWh
Nuclear	4–110 g CO_2e/kWh
Wind	7–56 g CO_2e/kWh
Geothermal	6–79 g CO_2e/kWh
Hydrothermal	70 g CO_2e/kWh
Ocean	2–23 g CO_2e/kWh

- Intergovernmental Panel on Climate Change (IPCC) AR5[12]

Nuclear power provides unambiguous additionality. When a company commits to building new nuclear capacity, there is no question about whether this power would be generated anyway. Unlike wind or solar projects, which are increasingly being built as the cheapest option for new power generation, new nuclear plants require long-term commitments and significant capital investment that would not materialize without dedicated corporate backing. This clarity of additionality is particularly valuable given the growing scrutiny of corporate clean energy claims.

Second, nuclear power's baseload characteristics eliminate many of the temporal matching problems associated with variable renewable energy. A nuclear plant provides consistent, reliable power 24/7, aligning perfectly with the more constant energy demands of server farms. This eliminates the need for complex time-matching schemes or the risk of inadvertently increasing emissions during periods of low renewable energy generation.

Third, nuclear power development largely avoids the resource competition issues that plague renewable energy procurement. Nuclear projects require different supply chains, expertise, and construction resources than wind and solar installations. While nuclear projects do compete for financial resources and investment – as any large infrastructure project would – they do not

[12] https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter7.pdf

directly compete for the same manufacturing capacity, materials, or specialized labor that are currently constraining renewable energy deployment. This differentiation in resource requirements means that nuclear development can proceed in parallel with renewable energy expansion rather than competing for the same limited supplies of solar panels, wind turbines, and related components.

The scale of nuclear power is also significant. A single nuclear plant can provide the same amount of carbon-free electricity as hundreds or thousands of acres of solar panels or wind turbines. This efficiency becomes increasingly important as AI's energy demands continue to grow. Nuclear power offers a path to meeting these massive energy needs without requiring vast tracts of land or overwhelming existing grid infrastructure.

Furthermore, nuclear power development creates new opportunities for innovation and technological advancement. Technology companies' involvement in nuclear projects, particularly in areas like small modular reactors or fusion technology, could help accelerate the development of next-generation nuclear technologies. This potential for technological synergy between the technology and nuclear industries could help drive down costs and improve safety, benefiting the entire energy sector. Safety has historically been a primary concern for nuclear power; modern designs and robust regulatory frameworks have led to strong safety records.[13] In fact, according to the NRC, the Kairos SMR commissioned for use by Google, employs engineered safety features for fission product containment and passive systems for decay heat removal, ensuring it meets or exceeds the safety criteria for modern reactors. The SMRs adhere to rigorous standards, such as maintaining safety under extreme conditions (e.g., earthquakes) and limiting radiological consequences below protective thresholds.[14]

Critics might point to the high costs and long development timelines of nuclear projects as disadvantages. However, these characteristics strengthen the additionality argument because nuclear power is not the cheapest or easiest option, as its development represents a genuine additional contribution to clean energy capacity. Moreover, technology companies' long-term planning horizons and strong balance sheets make them uniquely suited to support nuclear power development.

Nuclear power also offers valuable lessons for how we might approach other climate solutions, including CDR technologies. Just as nuclear power provides clear additionality and avoids resource competition, future climate solutions will need to demonstrate similar characteristics to be truly effective at scale, so the technology industry's embrace of nuclear power could serve as a model for approaching these challenges.

What makes nuclear power particularly compelling is its potential to provide the massive amounts of clean energy needed to power both our digital future and our climate solutions without compromising other decarbonization efforts. As we grapple with the dual challenges of exponentially growing energy demand and the urgent need to address climate change, nuclear power may offer the clearest path forward to provide the scale, reliability, and unambiguous additionality needed to meet these challenges head-on.

[13] https://e360.yale.edu/features/why-nuclear-power-must-be-part-of-the-energy-solution-environmentalists-climate
[14] https://www.nrc.gov/docs/ML2420/ML24200A115.pdf

Summary

The rapid expansion of AI capabilities has brought us to a critical juncture in the fight against climate change. The 1.5 million servers, running at full capacity, would consume at least 85.4 terawatt-hours (TWh) of electricity annually. This is equivalent to the total energy consumption of a country like Austria for a year. Traditional renewable energy procurement strategies, while well-intentioned, risk becoming part of the problem rather than the solution by competing with broader decarbonization efforts.

Google's bold move toward nuclear power represents more than just another corporate energy strategy – it signals a crucial evolution in how we think about additionality and leakage in the power sector. By choosing a power source that is unambiguously additional and avoids resource competition, if not financial competition, with other decarbonization efforts, technology companies can ensure their growth truly contributes to, rather than hinders, global climate goals.

This lesson should be heeded by the emerging CDR industry. As these technologies scale up, they, too, will face the same challenges of securing genuinely additional power sources. Nuclear power provides a template for how to approach these challenges, demonstrating that sometimes the most effective solutions may not be the easiest or cheapest, but rather those that most clearly advance global decarbonization efforts.

What is needed to decarbonize the world is bold strategies, and the drive for nuclear power may give us the clearest answer yet. While not the cheapest solution, nuclear power provides reliable and clean energy at a vast scale, and nuclear power's unique characteristics make it particularly well-suited to meet this challenge. The technology industry's embrace of nuclear power could be the catalyst that propels the world toward a truly carbon-neutral future, providing the massive amounts of additional, reliable, and clean energy required to power both our digital world and our climate solutions.

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About EcoEngineers

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